B Physics Results from DØ

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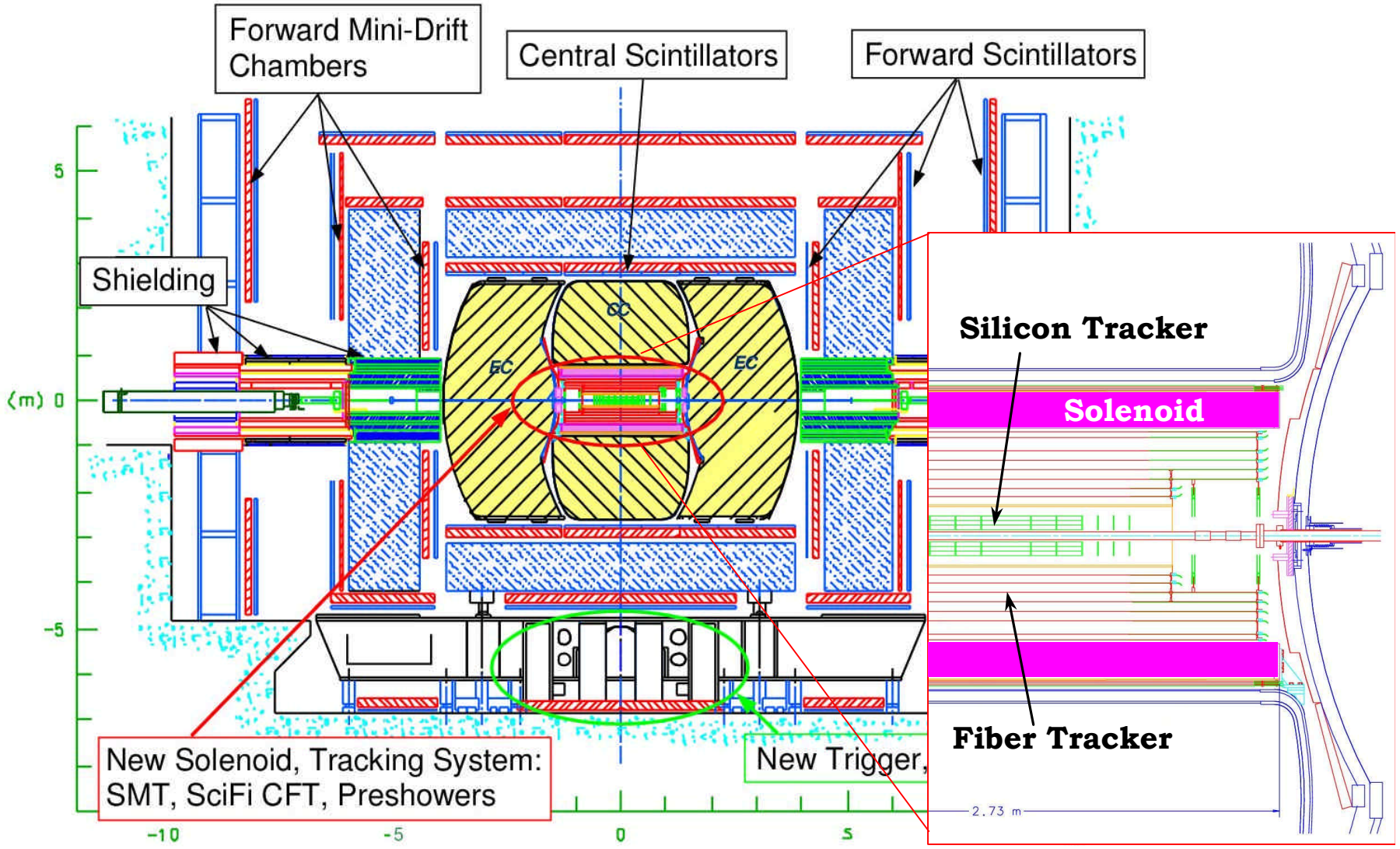
for the DØ Collaboration

Outline:

- Overview of DØ @ Run II
- Lifetimes
- Spectroscopy
- Prospects

CP&Mixing: See Paul Balm's talk this afternoon

The RunII DØ Detector



Detector Performance

SMT: 91% operational

CFT: 99% operational

CAL: >99.9% operational

MUON: >99.5% operational

Data Taking ε = 89% (M,J)

$\int \mathcal{L} dt$ = ~171 pb^{-1} (**LP**: 114 pb^{-1})

(April 2002 → July 13, 2003)

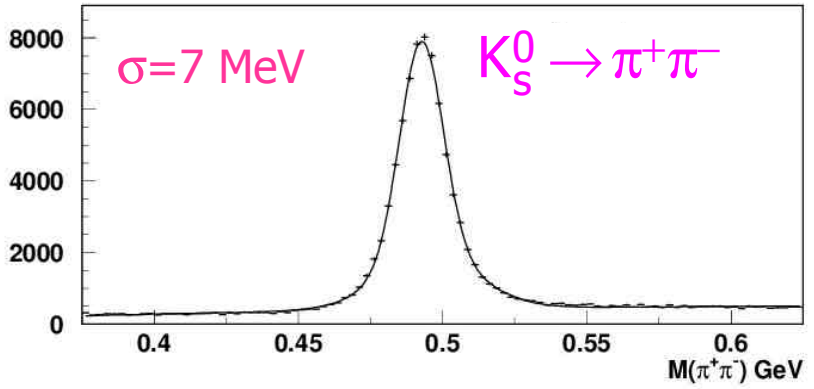
B Physics Triggers:

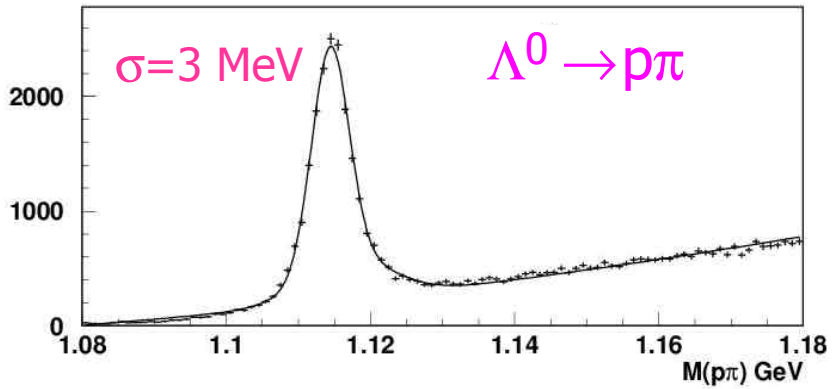
- μ+jets, EM e$^{\pm}$ (CAL)
- muons:

|η|<1: p_T > 3.5 GeV } di-μ

1<|η|<2: p_T > 2-2.5 GeV } single-μ

Track Calibration Samples:



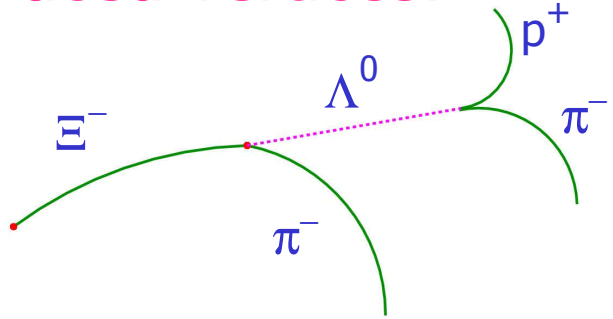


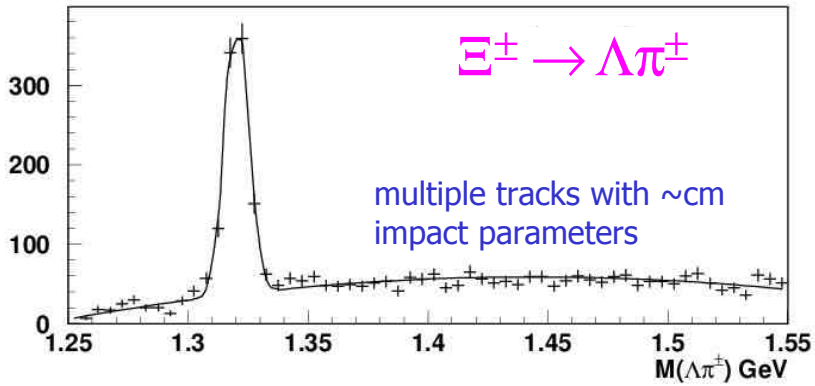
coming soon...

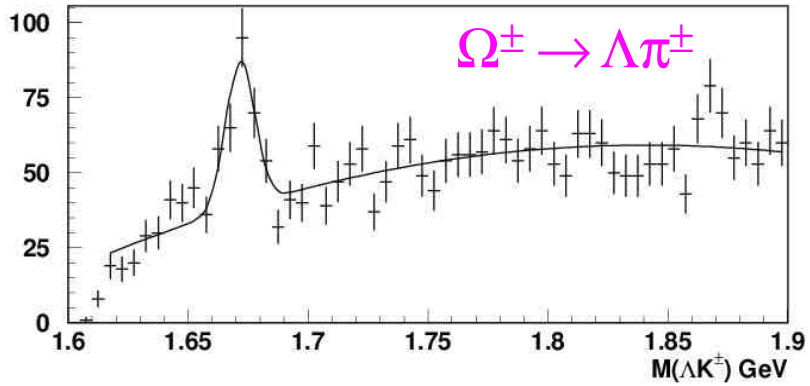
- L1 track-muon match (p_T>1.5 GeV |η|<1.7)
- L2 SMT Track trigger

Tracker Performance

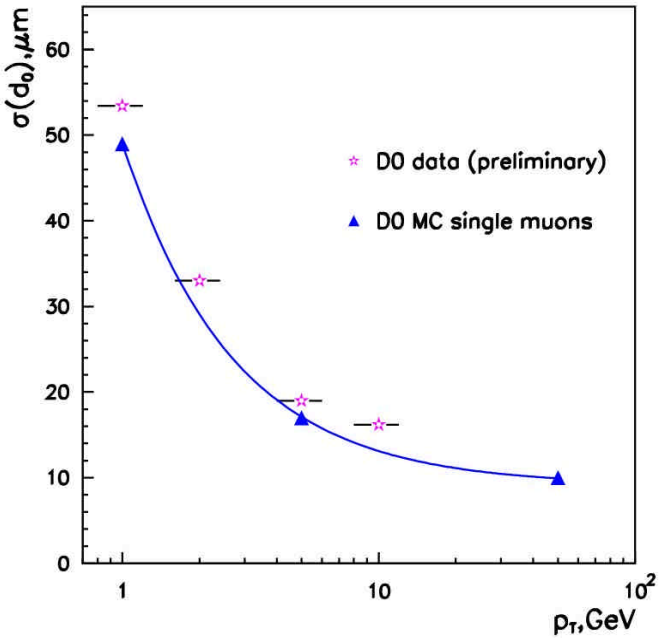
Displaced vertices:



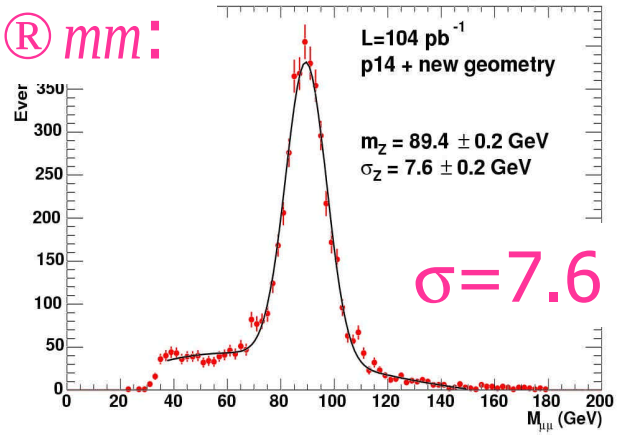




Impact Parameters:



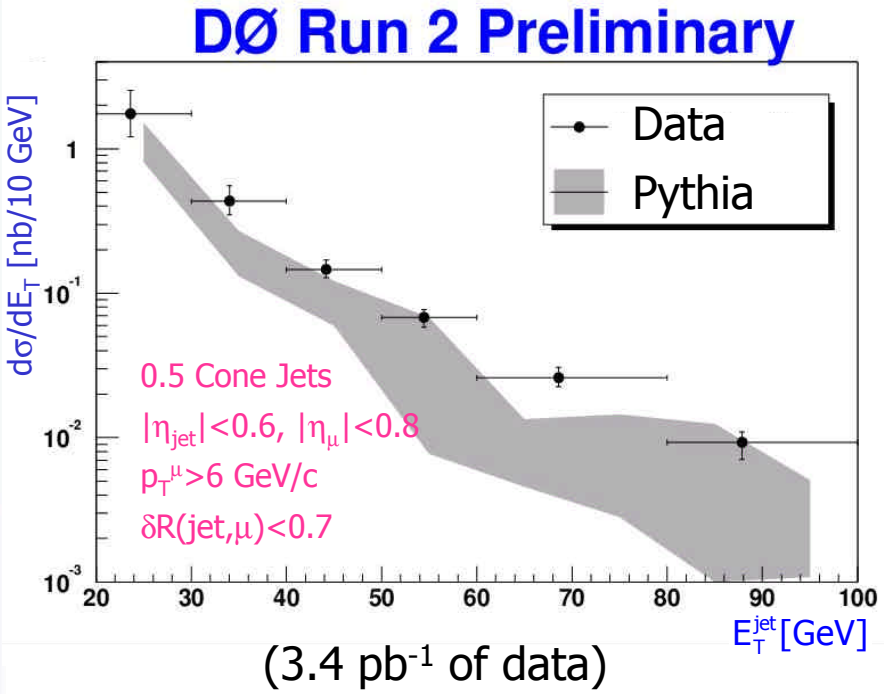
Z ® mm:



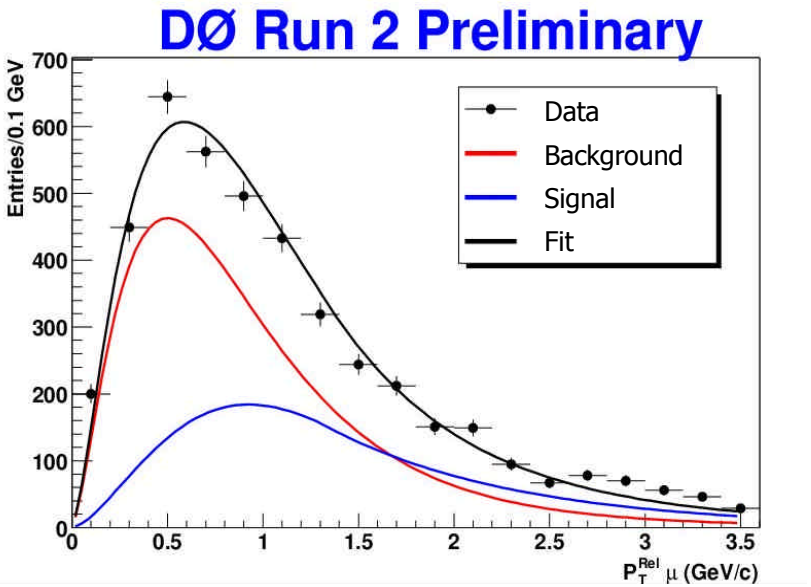
σ=7.6 GeV

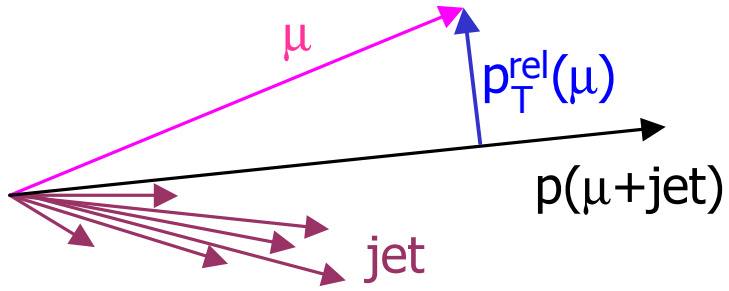
Inclusive b Cross Section

- Begin with μ+jet sample, measure cross section for this process:



(3.4 pb^{-1} of data)



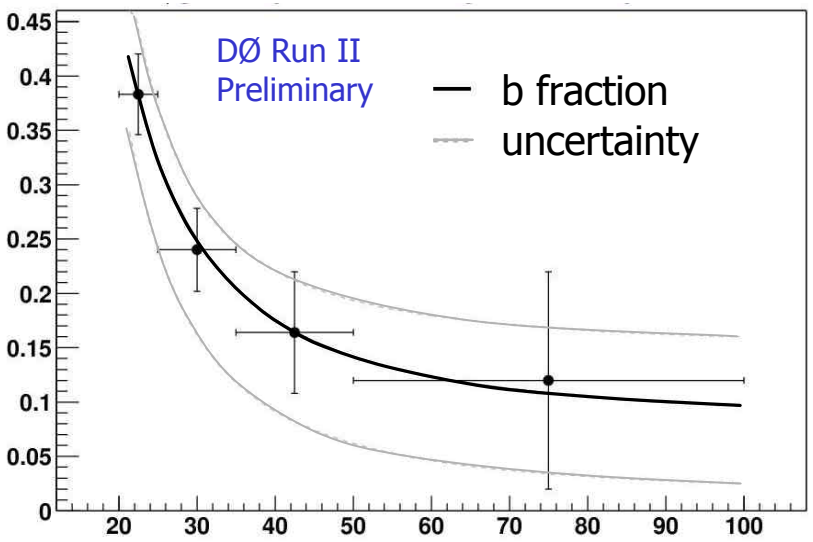


- Using muon p_T spectrum, fit for **b** and **non-b** content in bins of jet E_T

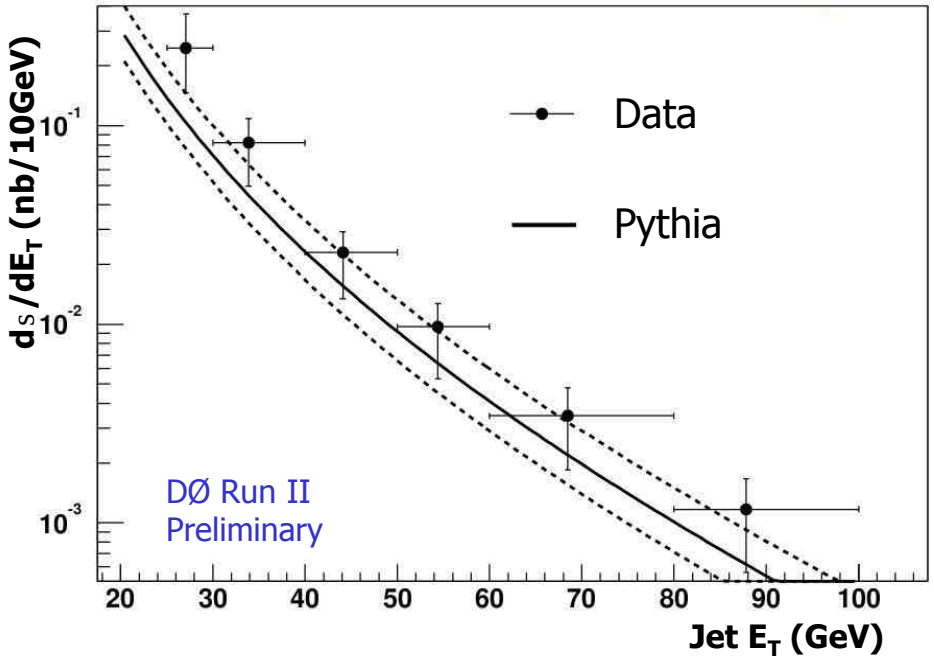
- Jet trigger eff. ~100% at E_T = 20 GeV
- Muon trigger efficiency ~55-70%
- Muon reco efficiency (43.7±0.8±2.2)%

Inclusive b Cross Section

fraction of b-jets from fit:



b production cross section:



Dominant Errors:

- jet energy resolution
- energy scale uncertainty

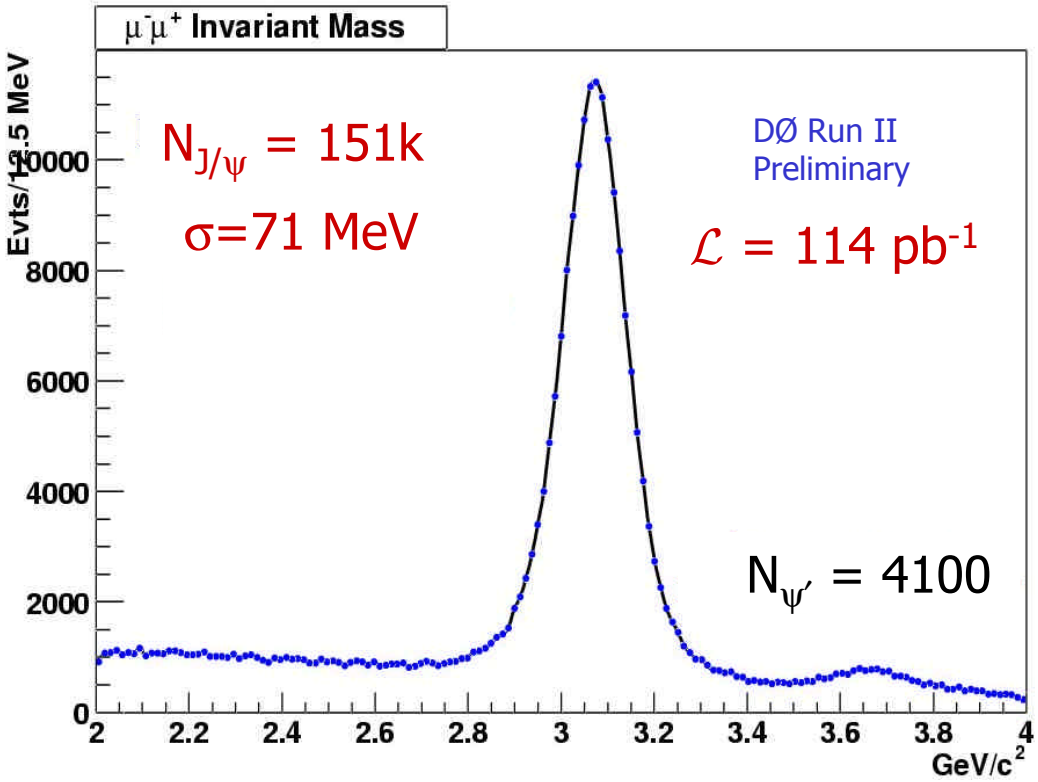
⇒ Energy resolution function used to "unfold" cross section to true jet energy

- "Pythia" = Pythia+CTEQ4M,$\delta R<0.3$
- Run I was compared to NLO(+MRSA')
  Nucl. Phys. **B483** 321 (1997)
- Different $\sqrt{s}$. Not directly comparable, but still **2-3x higher** than predictions

$J/y \to m^+m^-$ Sample

Our "in" to B Physics:

- ~1/6 from b-decay
- di-μ trigger running unprescaled since ~ Day 1
- access to many interesting/rare decays
- very clean signal
- (also helps in tracking commissioning)



Cuts:

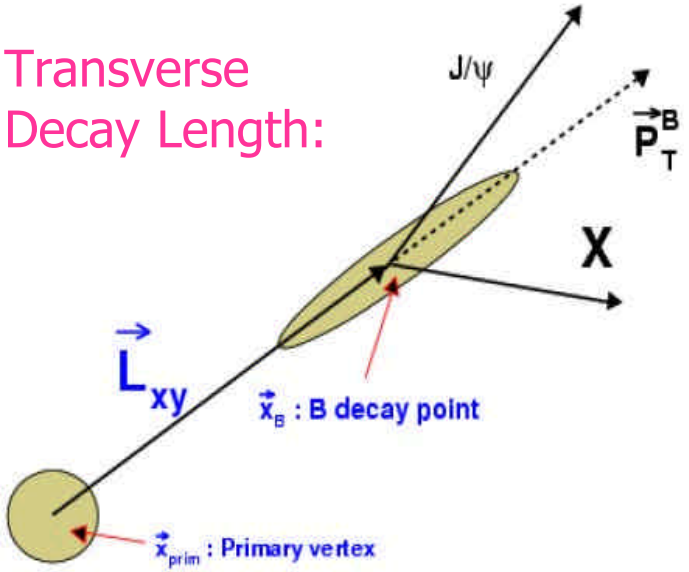
- Tracks: p_T>1.5 GeV, >3 SMT hits, >4 CFT hits
- $p_T(J/\psi)$ > 3 GeV
- (Yield very cut-dependent)

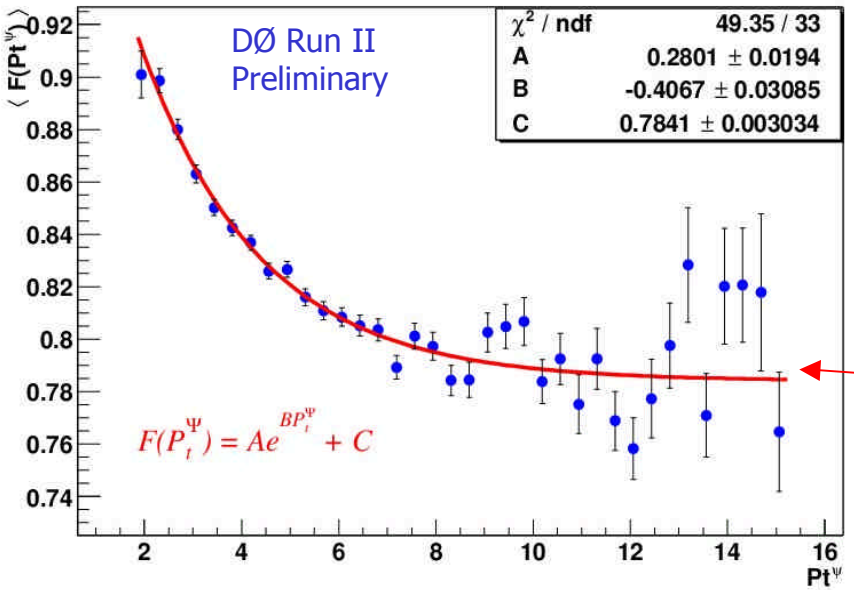
Comments:

- J/ψ mass about 1/3σ low; calibration not finalized yet (material, magnetic field)
- mass resolution close to MC expectation

Inclusive B lifetime

Transverse Decay Length:





- Use $B \to J/\psi X$ decays
- Decay length $\mathbf{L_{xy}}$ given by the primary vertex and the J/ψ vertex:

$$c\tau_{J/\psi} = L_{xy}\frac{M_{J/\psi}}{p_T^{J/\psi}}$$

- But, p_T of B unknown: Infer $\mathbf{ct_B}$ from $\mathbf{ct_{J/\psi}}$ by using MC correction:

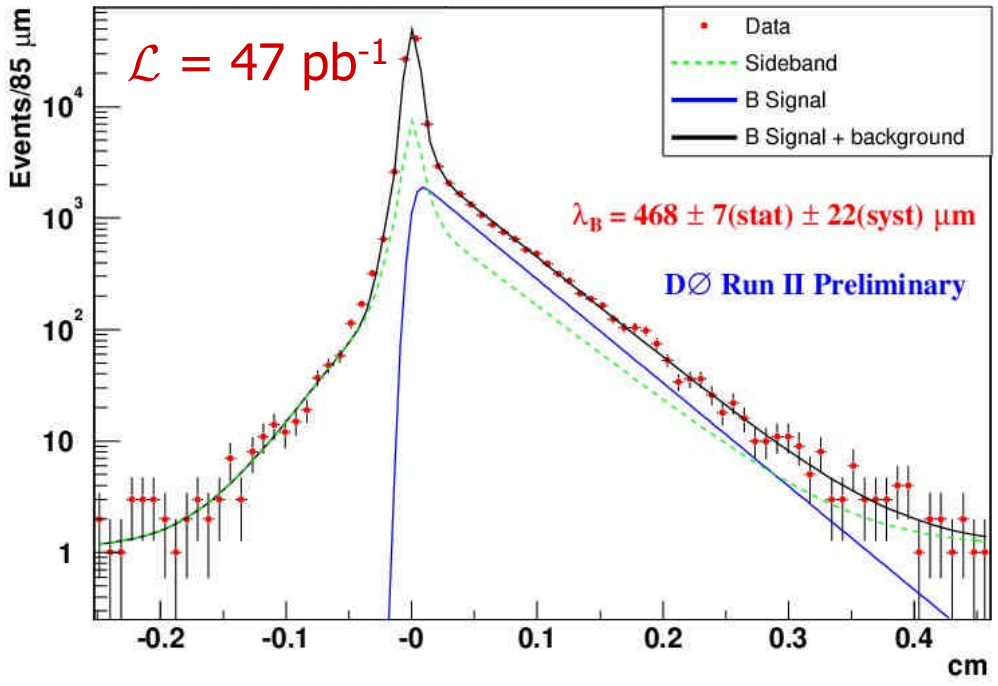
$$c\tau_B = \frac{\lambda_{J/\psi}}{\left\langle F(p_T^{J/\psi})\right\rangle}; \quad \left\langle F(p_T^{J/\psi})\right\rangle = \frac{M_{J/\psi}}{M_B}\frac{p_T^B}{p_T^{J/\psi}}$$

- Correction varies from 0.8-0.9 over visible momentum range

(Pythia+QQ, Run I tune)

Inclusive B Lifetime

Proper B decay length:



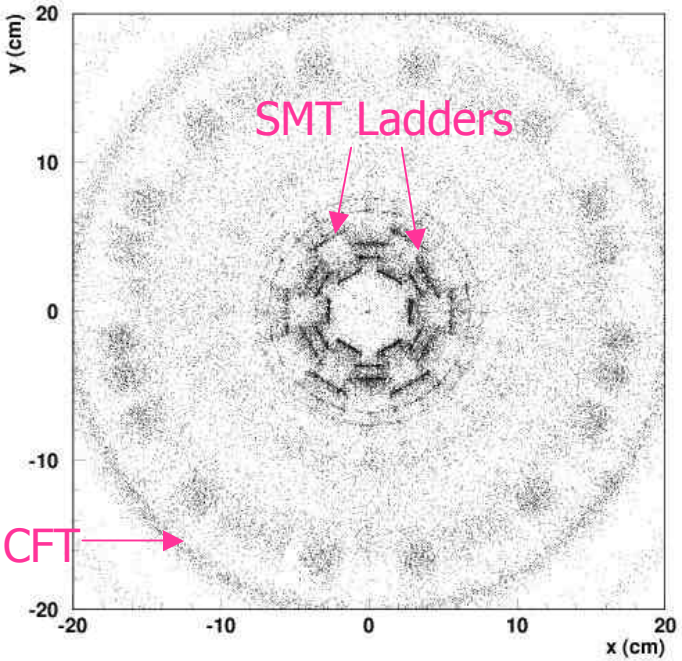
$$t_B = 1.561 \pm 0.024 \pm 0.074 \text{ ps}$$

PDG: $t_B = 1.564 \pm 0.014$ ps

- Prompt components:
  - J/ψ : pp → ccX
  - combinatorics
  - modelled as 2 Gaussians
- Exponential components:
  - B signal: b → cX
  - semileptonic b, c decays
- Gaussian params, background normalization from J/ψ sidebands
- Fit for:
  - B fraction
  - decay length
    - B fraction: 14.6%
    - Prompt J/ψ : 64.6%
    - Background: 21.3%

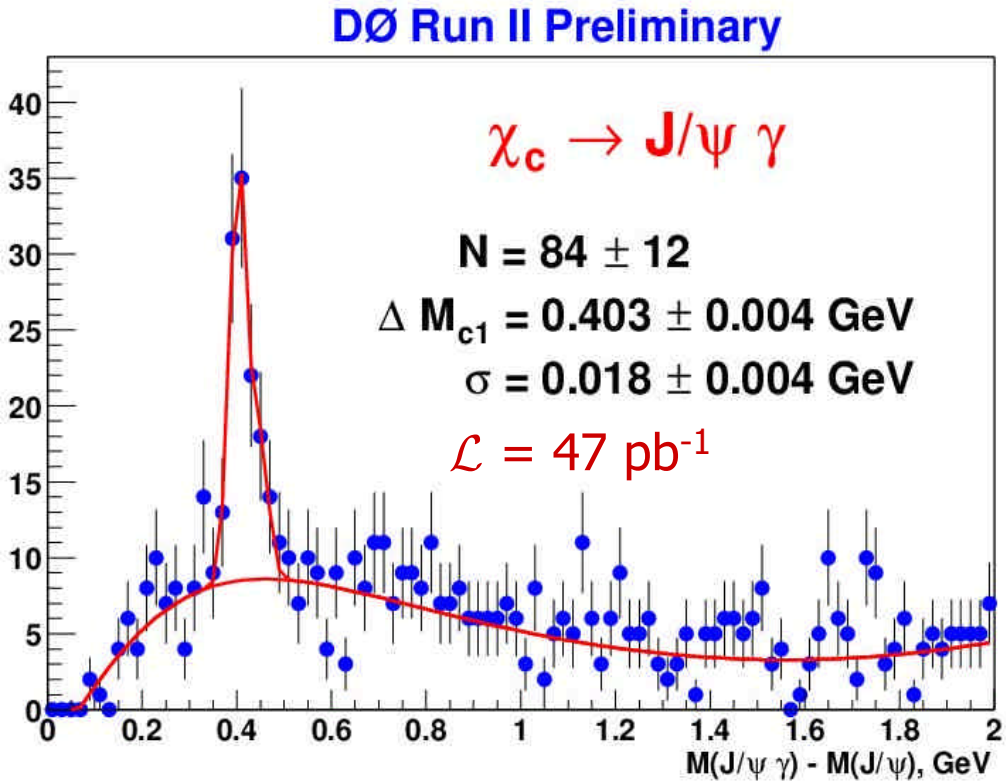
χ_c Reconstruction

Photon conversions:



- Looking for $b \rightarrow \chi_c + X$ (Br ~ 1-2%)
- Find χ_c in $\chi_c \rightarrow J/\psi\gamma$, $\gamma \rightarrow e^+e^-$
- $\varepsilon_\gamma \sim 0.4\%$, but 27% of J/ψ come from χ_c!

(CDF Run I, PRL **79**, 578 (1997))



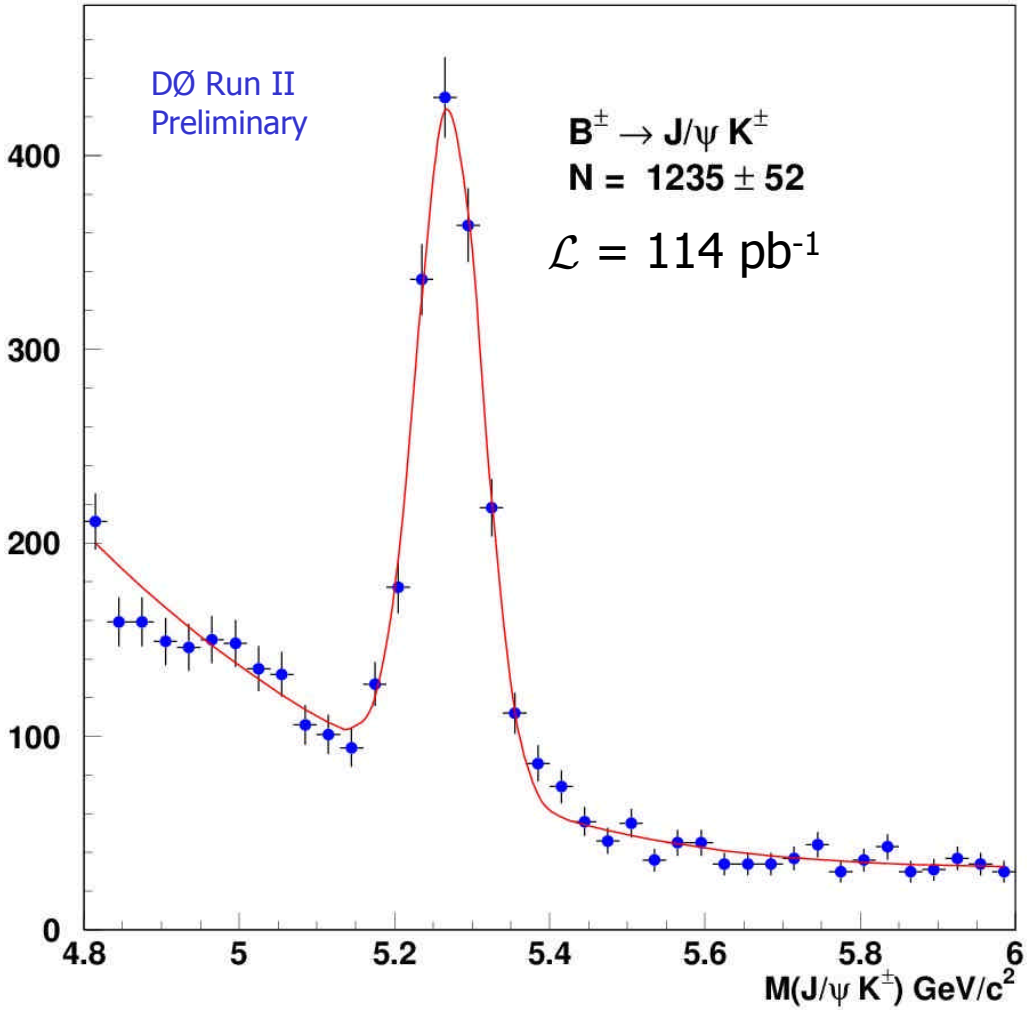
- can't yet separate χ_{c1}, χ_{c2}
  - fit with fixed $\Delta M_{1,2}$ = 46 MeV
- PDG $M(J/\psi\gamma)-M(J/\psi)$ = 414 MeV
- more data, improvements coming

Exclusive $B^{\pm}$ decays

J/ψ (p_T>4 GeV) associated with K track from same jet

Simple cuts:

- $p_T(K)>0.5$ GeV, $b(K)/\sigma_b>3$
- $L(B^+)/\sigma_L > 3$
- $\cos(\theta(L,p_B))> 0.9$
- $b(B^+)/\sigma_b<4$
- no particle ID (K/π)



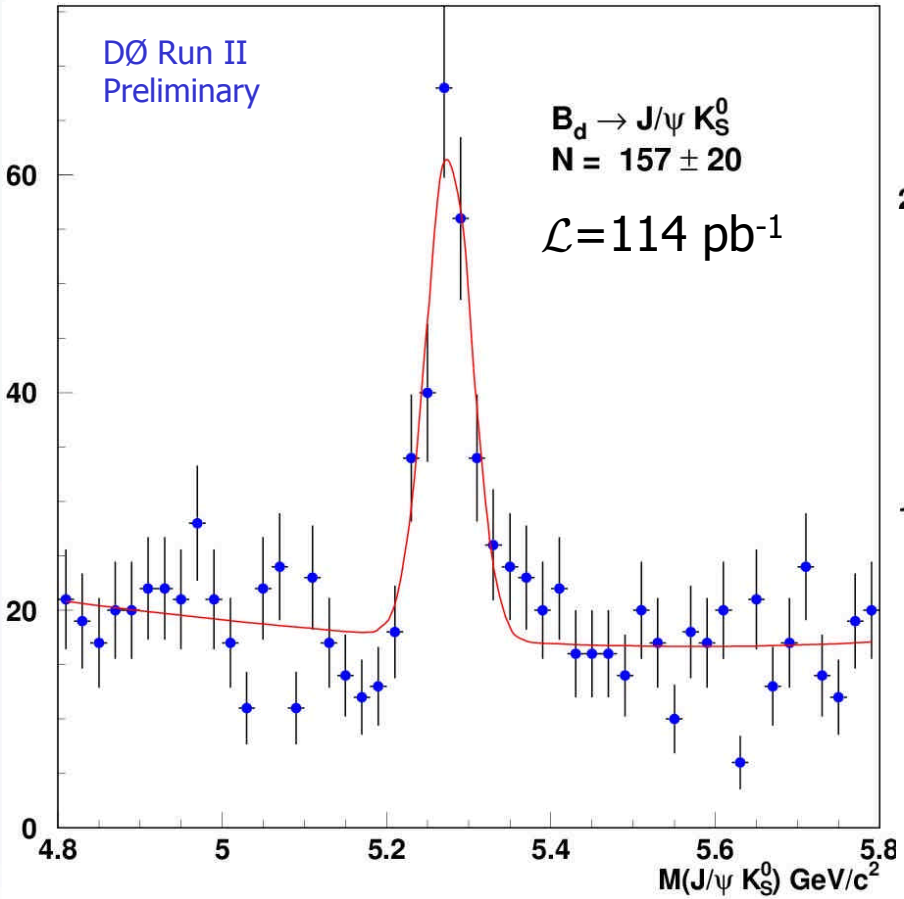
- Fully-reconstructed decays:
  - lifetime measurements
  - mixing (proper time resolution), flavor tagging studies

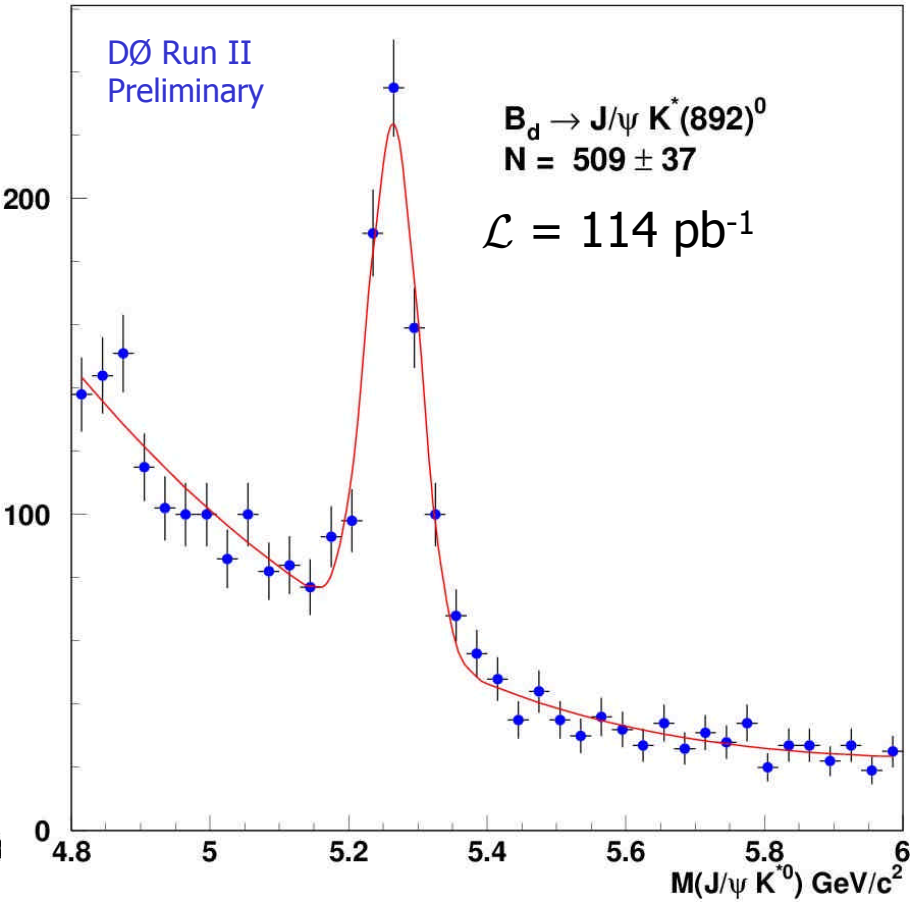
Exclusive B_d^0 decays

Combine J/ψ with ππ or Kπ:

(same cuts as B^+ analysis)

- $p_T(K_S) > 0.5$ GeV
- $p_T(K^*) > 1$ GeV





Exclusive B_s decays

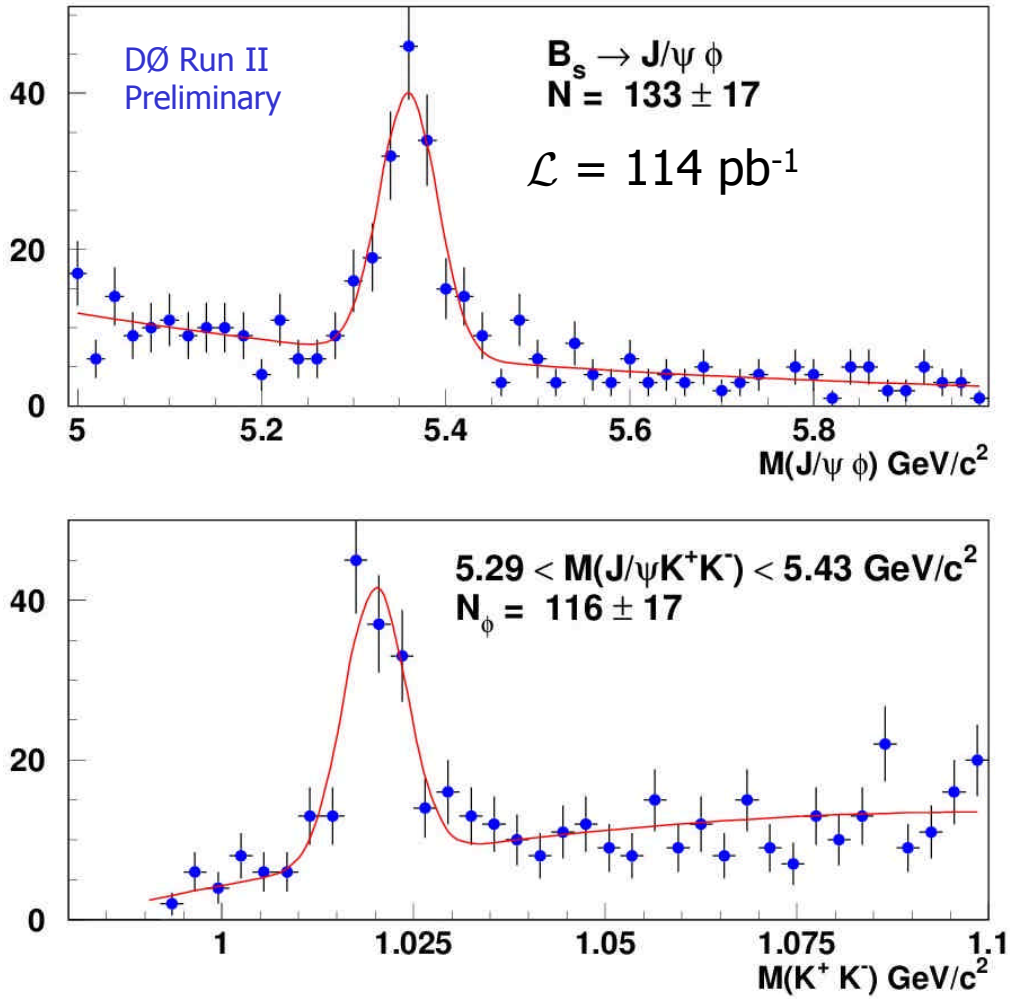
Combine J/ψ with KK:

$B_s \rightarrow J/\psi\phi$

- one of the useful modes for CP violation in the B_s sector:

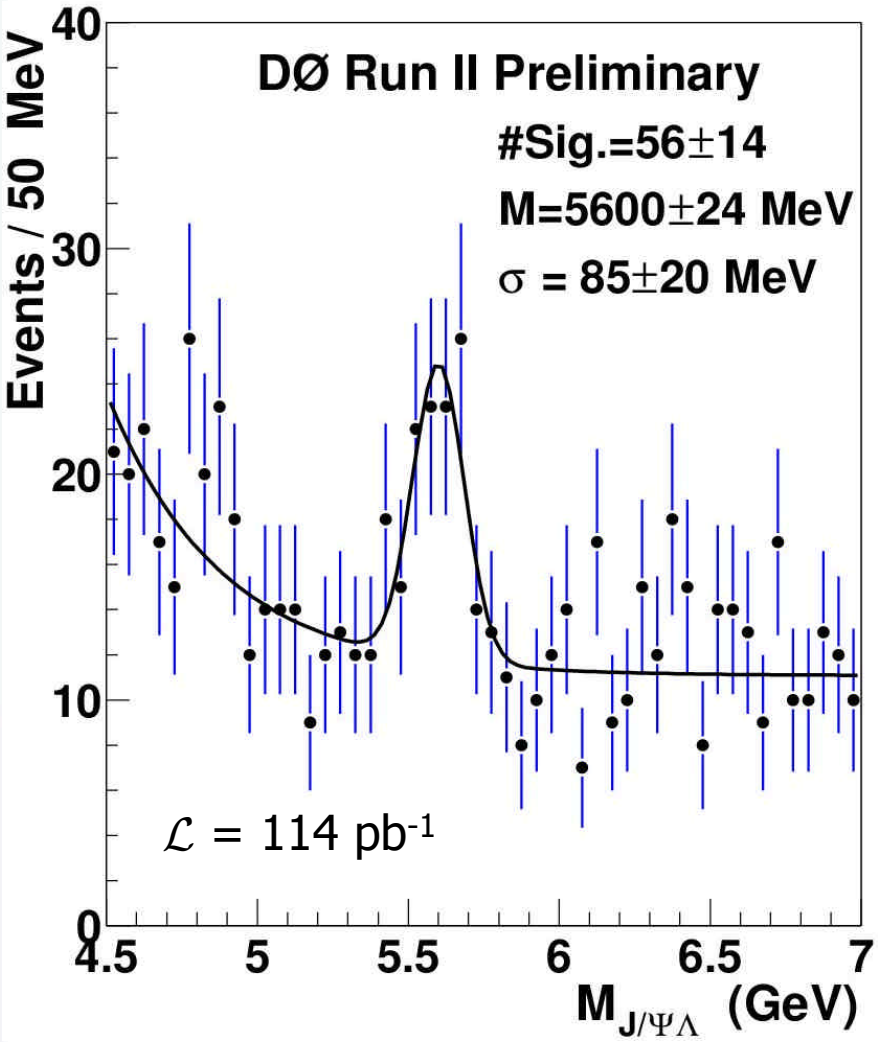
$$\mathrm{Im}(\lambda_{J/\psi\phi}) = (1 - f_{odd}) \sin 2\beta_s$$

- Measurement of asymmetry requires analysis of final state angular momentum
- could be diluted by cancellation of CP-odd and CP-even contributions
- large asymmetry would be unambiguous sign of new physics!
- B_s Lifetime$\rightarrow \Delta\Gamma_s$



Stay tuned!

Exclusive Λ_b Decays



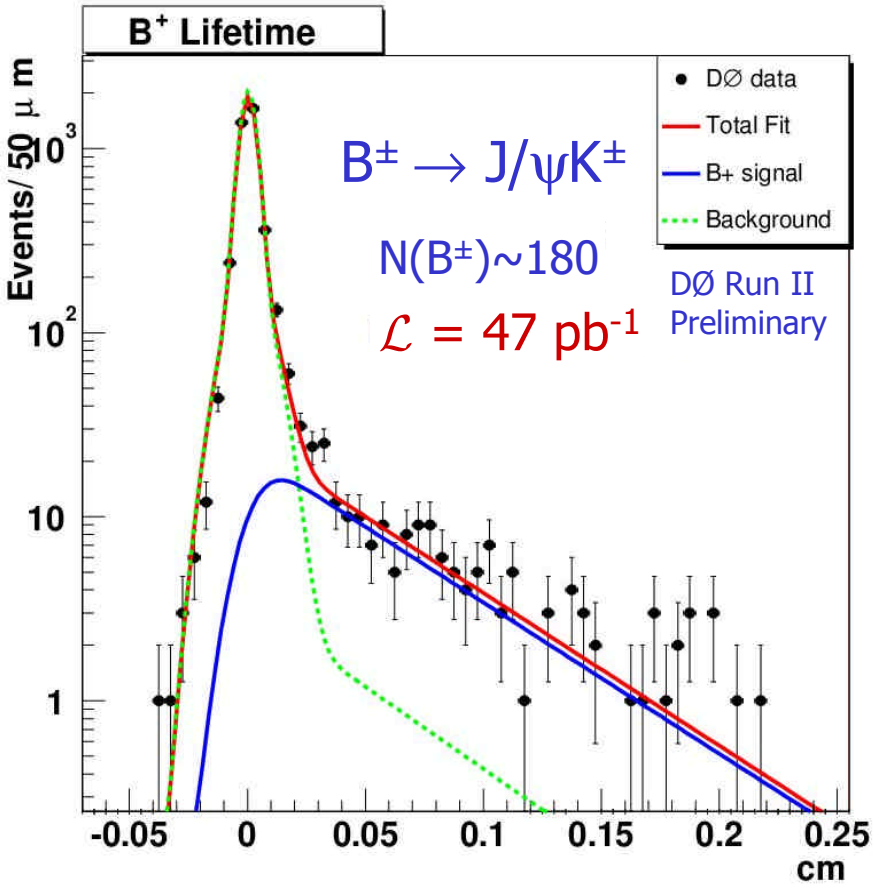
Combine J/ψ with a Λ:

$\Lambda_b \rightarrow J/\psi\Lambda$

- now updated with full RunII statistics
- Being used for Λ_b lifetime measurement
- look for result at Lepton-Photon

Charged B Lifetime

Proper B decay length:



Using $B^{\pm} \rightarrow J/\psi K^{\pm}$ mode

- full reconstruction
  - no hadronization uncertainties
  - excellent proper time resolution

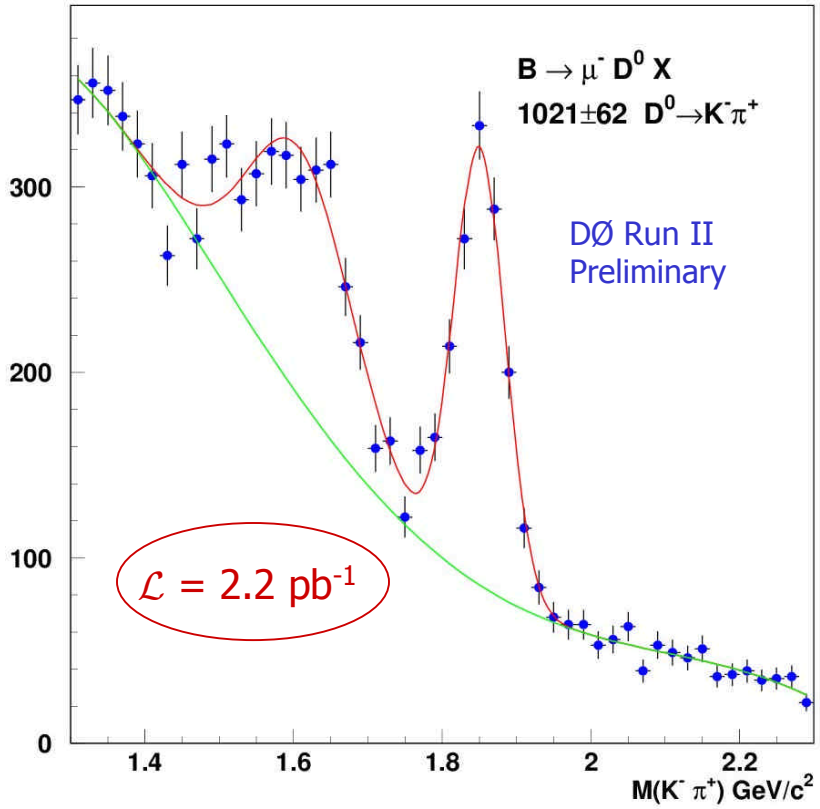
Details:

- B^{+} event selection without decay length cut
- R. Sideband used for background
- Non-($B^{\pm} \rightarrow J/\psi K^{\pm}$) contribution (12%) from other B decays taken from MC

$t_{B^+} = 1.76 \pm 0.24\ (\text{stat})\ \text{ps}$

PDG: $t_{B^+} = 1.674 \pm 0.018\ \text{ps}$

Inclusive Semi-leptonic B Decays



- High Yield!
- excellent source of B hadrons for tagging, trigger, physics studies

- Single muon triggers!
  - $|\eta|<2$, $p_T(\mu) > 2$-3.5 GeV
- simple cuts:
  - $p_T(\mu) > 2$ GeV, $p_T(\pi,K) > 1$ GeV
  - $(b(\pi,K)/\sigma_b)^2 > 6$, $L(D)/\sigma_L > 4$
  - $\cos(\theta(\vec{L},\vec{p}_D)) > 0.95$
  - $\chi^2_{vtx}(\mu D) < 4$
  - 2.3 GeV < M(μD) < 5.5 GeV
- Here, only $D^0 \to Kp$ mode used
  - Obviously, can also use
    - $B \to m^{\pm} D^{*} X$
    - $B \to m^{\pm} D^{\pm} X$
    - $B \to m^{\pm} D_s X$

Conclusions/Prospects

- DØ is well-positioned to contribute substantially to our B-physics knowledge in RunII
  - excellent tracking, muon coverage
  - high-efficiency running
  - high yields in many useful final states
  - flavor tags look promising (See Paul Balm's talk)
- Many new results coming for Lepton-Photon
  - updates on lifetimes (B^+,Λ_b,B_s, ...)
  - first look at B_d/B_s semi-leptonic decays
  - rare decays
- Expect DØ to be competitive!